AD 426958

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

64-6

COPY NO. 51 OF 100

TECHNICAL MEMORANDUM 1295

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

CHARLES LENCHITZ
GAYTON SILVESTRO

JUNE 1963

AMCMS 5011.11.838001 DA PROJECT NO. 1A0105013010

PICATINNY ARSENAL
DOVER, NEW JERSEY

The findings in this Report are not to be construed as an official Department of the Army position.

DISPOSITION

Destroy this report when it is no longer needed. Do not return.

DDC AVAILABILITY NOTICE

Qualified requesters may obtain copies of this report from DDC.

Picatinny Arsenal Technical Memorandum No. 1295

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

by

Charles Lenchitz

Gayton Silvestro

June 1963

Reviewed by:

CHARLES LENCHITZ
Chief, Ballistics and Combustion Research Section

Approved by:

JEAN P. PICARD
Chief, Propellants Laboratory

Propellants Laboratory
Picatinny Arsenal
Dover, New Jersey

TABLE OF CONTENTS

	Page
Abstract	1
Introduction	2
Results	
A. Calibration Experiments	2-4
B. Combustion Experiments	4-6
Discussions of Results	7
Experimental	8
References	9
Table I	
Table II	
Distribution List	

ABSTRACT

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an α Al_2O_3 residue. Calculation of the heat of formation from the reaction:

$$C_6H_{24}O_{18}Cl_3N_{12}Al(s) + 3C_2(g) + 1789.5\ H_2O(l) \longrightarrow$$

$$6CO_2(g) + 6N_2(g) + \tfrac{1}{2}\ Al_2O_3(c) + 3\ (HCl.600\ H_2O)$$

gives a value of -691.53 kcal/mole (at constant pressure and 25°C).

INTRODUCTION

Exploratory combustion experiments with hexaurea Aluminum III perchlorate* indicated that the compound burns smoothly, and leaves a white crystalline residue. An x-ray analysis of this residue showed that only α Al_2O_3 (corundum) was formed**.

Although it was planned to circumvent some of the corrections needed for this type of compound by running comparison experiments it was decided to combust the sample separately because only four 1.2g pellets remained. (A subsequent sample sent to these laboratories caked and turned grey indicating that the aluminum may have separated from the complex).

RESULTS

A. Calibration Experiments

The calorimeter was calibrated with Parr Instrument Company benzoic acid (calorific value 6318 cal/g). The bomb was charged with 35cc of As_2O_3 solution containing the same quantity of HCl as is produced in the sample combustion. A weighed quantity of glass wool saturated with this solution was placed above the sample cup. The benzoic acid was ignited with platinum wire and the rotation was started after the first resistance reading was taken.

Because of these bomb conditions a Washburn correction had to be included for the combustion of benzoic acid. A total of nine corrections were therefore made for each of the five calibration experiments. These corrections are listed in Table 1 and briefly described below.

Step (1) is a correction for the compression of 35cc of solution to 30 atmospheres i.e.

$$\left[\frac{\partial E}{\partial P}\right]_1^{30}$$

The solution was treated as pure water.

* This compound was supplied by Allied Chemical, General Chemical Division, Morristown, N.J.

** X-ray analysis performed by J. Campisi, Propellant Research Section.

Step 2 - Correction for the compression of benzoic acid i.e.

$$\left[\frac{\partial E}{\partial P}\right]_1^{30}$$

Step 3 - Correction for the solubility of oxygen in the solution. The solution again being treated as pure H_2O i.e.

$$[\Delta E_{soln}]$$

Step 4 - Correction for the compression of oxygen i.e.

$$\left[\left(\frac{\partial E}{\partial P}\right)_T\right]_0^{30}$$

Step 5 - Correction for the dilution of the HCl solution with water formed by the reaction.

$$[\Delta E_{dilnHCl}]$$

Step 6 - Correction for the dissolved CO_2 in water and its expansion to unit fugacity.

$$[\Delta E_{soln\ CO_2}]$$

The solution is assumed to be pure water.

Step 7 - Correction for dissolved oxygen in water and its expansion to unit fugacity. $[\Delta E_{soln\ O_2}]$

Step 8 - Correction for expansion of the gas phase to unit fugacity.

$$\left[\Delta E_{gas}\right]^{0}_{P_{final}}$$

Step 9 - Correction for the decompression of the aqueous phase.

$$\left[\frac{\partial E}{\partial P}\right]^{0}_{P_{final}}$$

A detailed description of the standardization of calorimeters and the required corrections is described by Neugebauer Ref (1) and by Hubbard, Scott, and Waddington and Prosen Ref (2). The constants used for making these corrections were taken from Ref (2). It should be noted that some corrections are not included because they were deemed insignificant.

B. Combustion Experiments

Combustion of the sample was made in the same environment as in the calibration experiments. Corrections are more complicated than in a routine halogen compound because of the presence of aluminum and nitrogen. 35cc of As_2O_3 solution was used. A similar quantity of glass wool was saturated with this solution (as in the calibration experiments) and the remaining solution placed in the bottom of the bomb. The corrections which were made are shown in Table 2 and are explained below.

Step 1 - Correction for the vaporization of water before firing.

$$\left[\Delta E_{i\ vap}\right]$$

Step 2 - Correction for compression of the 35cc of solution treated as pure water.

$$\left[\left(\frac{\partial E}{\partial P}\right)_T\right]^{30}_{1}$$

Step 3 - Correction for the compressibility of the substance was not made. The magnitude of this correction is not significant (in these experiments).

Step 4 - Correction for the solubility of O_2 and N_2 in the solution (treated as pure H_2O). $[\Delta E_{soln}]$

Step 5 - Correction for the compression of the oxygen i.e.

$$\left[\left(\frac{\partial E}{\partial P}\right)_T\right]_0^{30}$$

Step 6 - Correction for the solution of CO_2 in the solution (treated as pure water) i.e. $[\Delta E_{soln}]$

Step 7 - Correction for the solubility of O_2 and N_2 in solution (treated as pure H_2O).

Step 8 - Correction for decompression of the liquid phase.

$$\left[\left(\frac{\partial E}{\partial P}\right)_T\right]_{30}^{1}$$

Step 9 - Correction for nitric acid. Aliquots of each of the four bombs washings were mixed and the nitric acid content was analyzed by the Devarda Method References (4).

Step 10 - Correction for the dilution of HCl to 600 H_2O.

$$\left[\Delta E_{dilu\ HCl}\right]$$

Step 11 - Correction for the reduction of Cl_2 to HCl via

$$As_2O_3 \longrightarrow As_2O_5$$

Step 12 - Correction for decompression of gaseous phase i.e.

$$\left[\left(\frac{\partial E}{\partial P}\right)_T\right]^{0}_{P_{final}}$$

Step 13 - Correction for condensation of water vapor to liquid i.e.

$$\left[\Delta E_{vap}\right]$$

If the rotation of the bomb is not started at the mid time of the calorimetric experiment and continued through the end of the final rating period a correction for rotation should be included. In the combustion experiments the rotation was started, (approximately), 63 seconds before the mid time. In the calibration experiments the comparative period is 62 seconds. The estimated heat input from bomb rotation, during this period (62-63 seconds) is less than 2 calories. If the correction is therefore omitted from both the calibration and combustion experiments it will not affect the results significantly.

DISCUSSION OF RESULTS

No attempt will be made to estimate the accuracy of the calculated heat of formation because the recovered chloride in the wash water varies from 92.2% to a maximum of only 96.3% of the calculated value. In one determination where this laboratory found 0.509 g chloride an independent check by the Analytical Section yielded 0.497 g. The Volhard Method was used in both cases. Bubbling the gases of combustion through a NaOH solution showed no chloride indicating that none was lost in the exhaustion process. Washing the α Al_2O_3 with hot water also showed the absences of chloride. Based on this evidence it must be concluded that the sample purity is questionable and that the result obtained must be used as an approximate value.

It should be noted that in the two determinations where the gases were analyzed for CO_2, 98% of the carbon was accounted for. Add to this the solubility of this gas in 35cc of solution remaining in the bomb and one can anticipate a recovery approximating the calculated value.

One additional observation is worthy of note and that is the final form of the Al_2O_3. Although x-ray analysis showed only α crystals one cannot assume that the amorphous form is completely absent. This assumption seems to be made by Snyder and Seltz in their work on the heat of formation of Al_2O_3 Reference (3). No attempt was made to quantitatively recover the Al_2O_3.

EXPERIMENTAL

Equipment

The heat of combustion was measured in a rotating bomb calorimeter. The bomb was made by the Parr Instrument Company, Moline, Illinois, and is platinum lined. The calorimeter is a submarine type manufactured by the Precision Scientific Company for accomodating a stationary bomb. A new bucket was therefore designed which accepts the rotating bomb and fits into the calorimeter bath.

The design of the bucket and rotating mechanism is based on prints obtained from the U.S. Bureau of Mines at Bartlesville, Oklahoma.

Resistance measurements were made with a platinum resistance thermometer and a G-2 Mueller Bridge each of which was purchased from the Leeds and Northrup Company, Philadelphia, Pa.

The method used is standard and is adequately described in Reference 2.

Sample

The sample was obtained from Allied Chemical Corp in Morristown, N.J. and combusted as received. Their chemical analysis of the sample is as follows:

	Found	Calculated
Cl	15.5	15.5
Al	3.7 - 3.8	3.935
H	3.99	3.528
C	10.75	10.51
N	---	24.51

A subsequent sample received from Allied Chemical Corporation showed a N content of 24.32 - 24.42%.

REFERENCES

1. Neugebauer, C.A., "Standard Heats of Formation by Rotating and Stationary Bomb Calorimetry", Thesis Submitted for Ph D (Chemistry) University of Wisconsin 1957.

2. a. Rossini, F.D. "Experimental Thermochemistry", Interscience Publishers, Inc., N.Y. Vol I 1956.

   b. Skinner, H.A. "Ibid, Vol. II 1962.

3. Snyder, P.E. and Seltz, H. "The Heat of Formation of Aluminum Oxide", Journal American Chemical Soc. 67,683 (1945).

4. Reiman, Neuss, Naiman, "Quantitative Analysis "International Chemical Series, McGraw Hill Book Co., N.Y. 1942.

Calibration Data
TABLE 1

Run No.		1	2	3	4	5	
Wt. (vac)	grams	.997635	1.039035	1.061435	.972285	1.067680	
ΔT (corr)	ohms	.1581027	.1656443	.1683906	.1548271	.1699340	
HNO_3 (corr)	cals	-1.48	-1.72	-1.48	-1.35	-1.72	
Std States	(1)	1.89	1.89	1.89	1.89	1.89	
Corr	(2)	.08	.08	.09	.08	.09	
	(3)	3.93	3.93	3.93	3.93	3.93	
	(4)	17.98	17.98	17.98	17.98	17.98	
	(5)	-2.16	2.25	2.29	2.10	2.31	
	(6)	-17.20	17.89	18.26	16.78	18.58	
	(7)	-3.32	3.29	3.27	3.33	3.27	
	(8)	-21.66	21.85	21.94	21.56	21.96	
	(9)	-2.11	-2.11	2.11	2.11	2.11	
Total Cals.		-22.57	-23.51	-23.98	-22.00	-24.34	
Water Equivalent Cals/Ohm		40,019	39,783	39,976	39.828	39,849	39,891 ± 45

Sample Data

TABLE 2

Run No.		1	2	3	4	
WT (vac)	grams	1.2256406	1.2093636	1.1955906	1.2161406	
Δ T (corr)	ohms	.04258226	.04116624	.04068581	.04122991	
CO_2 calculated	grams	---	---	.46015	.46807	
CO_2 recovered	grams	---	---	.45150	.45730	
Cl calculated	grams	---	.18750	.18536	.18855	
Cl recovered	grams	---	.17724	.17086	.18149	
% CO_2 recovered		---	---	98.1	97.7	
% Cl recovered		---	94.5	92.2	96.3	
Standard States	(1)	4.26	4.26	4.26	4.26	
(corr)	(2)	-1.89	-1.89	-1.89	-1.89	
	(3)	---	---	---	---	
Cals	(4)	-3.93	-3.93	-3.93	-3.93	
	(5)	-17.98	-17.98	-17.98	-17.98	
	(6)	3.38	3.33	3.30	3.35	
	(7)	4.07	4.07	4.07	4.07	
	(8)	2.02	2.02	2.02	2.02	
	(9)	None found				
	(10)	-.16	-.15	-.14	-.15	
	(11)	35.09	31.18	21.06	32.39	
	(12)	20.45	20.53	20.50	20.56	
	(13)	-4.34	-4.34	-4.34	-4.34	
Total (corr) Cals		40.91	37.10	26.93	38.36	
ΔT x 39,891		-1698.65	-1642.16	-1623.00	-1644.70	
Heat liberated	cal/g	-1352.55	-1327.19	-1334.96	-1320.85	-1333.9 $\pm$ 6.7
Heat liberated	kcal/mole	-927.4	-910.0	-915.3	-905.7	-914.6

ΔH_c (corr to std pressure) kcal/mole = -909.3

DISTRIBUTION LIST

	Copy No.
Commanding General U. S. Army Materiel Command ATTN: AMCRD-RS - Mr. J. Crellin AMCRD-RS - Mr. J. Chalmers Washington 25, D. C.	 1 2
Commanding General U. S. Army Munitions Command ATTN: AMSMU RE-RE, Dr. Erway AMSMU EE-EE, Mr. J. E. Rainier Dover, New Jersey	 3 4
Commanding General U. S. Army Missile Command ATTN: AMSMI-RKK - Dr. D. Sayles AMSMI-RKX - Mr. F. James Redstone Arsenal, Alabama	 5-6 7
Commanding General U. S. Army Missile Command Redstone Scientific Information Center ATTN: Chief, Document Section Redstone Arsenal, Alabama	 8-10
Commanding Officer U. S. Army Ammunition Procurement & Supply Agency ATTN: SMUAP-AREL Joliet, Illinois	 11
Commanding Officer U. S. Army Ballistic Research Laboratories ATTN: AMXBR-BRL-1 Aberdeen, Maryland	 12-13
Commanding Officer Frankford Arsenal ATTN: SMUFA-Propellants & Explosives Section, 1331 Philadelphia 37, Pennsylvania	 14

	Copy No.
Commanding Officer Picatinny Arsenal ATTN: Technical Information Section Dover, New Jersey	15-20
Commanding General White Sands Missile Range ATTN: Technical Library New Mexico	21-23
Commanding Officer Harry Diamond Laboratories ATTN: Library Connecticut Ave. & VanNess St., N. W. Washington 25, D. C.	24
Commanding Officer Army Research Office Duke Station Durham, North Carolina	25
Army Research Office (CRD-F) Arlington Hall Station Arlington, Virginia	26
Bureau of Naval Weapons ATTN: RMMP-2 RMMP-331 Department of the Navy Washington 25, D. C.	27 28
Commander U. S. Naval Air Missile Test Center ATTN: Technical Library Point Mugu, California	29-30
Commanding Officer U. S. Naval Propellant Plant ATTN: Research & Development Dept. Indian Head, Maryland	31-32
Commander U. S. Naval Weapons Laboratory ATTN. Technical Library Dahlgren, Virginia	33

	Copy No.
Commander U. S. Naval Ordnance Laboratory ATTN: Library White Oak Silver Spring, Maryland	34
Commander U. S. Naval Ordnance Test Station ATTN: Technical Library Branch China Lake, California	35-37
Commanding Officer Office of Naval Research 1030 E. Green Street Pasadena 1, California	38
Director Special Projects Office Department of the Navy Washington 25, D. C.	39
Bureau of Naval Weapons Department of the Navy Washington 25, D. C.	40
Commander Air Force Flight Test Center ATTN: FTRS Edwards Air Force Base, California	41
Commander Air Proving Ground Center ATTN: Technical Library Eglin Air Force Base Florida	42
Defense Documentation Center Cameron Station Alexandria, Virginia, 22314	43-62
Chemical Propulsion Information Agency The Johns Hopkins University Applied Physics Laboratory 8621 Georgia Avenue Silver Spring, Maryland	63-65

	Copy No.
Scientific and Technical Information Facility ATTN: NASA Representative (S-AK/DL) P. O. Box 5700 Bethesda, Maryland	66-72
Thiokol Chemical Corporation Redstone Division Huntsville, Alabama	73
Rohm & Haas Company Redstone Arsenal Research Division ATTN: Librarian Huntsville, Alabama	74
British Defense Staff British Embassy ATTN: Scientific Information Officer 3100 Massachusetts Avenue Washington, D. C.	75-79
Defense Research Member Canadian Joint Staff (W) 2450 Massachusetts Ave. Washington 8, D. C.	80-83

AD Accession No.
Picatinny Arsenal, Dover, New Jersey

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

Charles Lenchitz, Gayton Silvestro

Technical Memorandum No. 1295, DA Proj. 1A0105013010 June 1963, 9 pp, tables.

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an Al_2O_3 residue. Calculation of the heat of formation from the reaction:

$C_6H_{24}O_{18}Cl_3N_{12}Al(s) + 3O_2(g) + 1789.5\ H_2O(l)$

$6CO_2(g) + 6N_2(g) + \frac{1}{2}\ Al_2O_3(c) + 3\ (HCl.600\ H_2O)$

gives a value of −691.53 kcal/mole (at constant pressure and 25°C).

UNCLASSIFIED

1. Perchlorates – Combustion
2. Title

I. Lenchitz, Charles
II. Silvestro, Gayton

UNITERMS

Heat
Formation
Hexaurea
Aluminum III
Perchlorate
Combustion
Bomb
Aluminum oxide

UNCLASSIFIED

AD Accession No.
Picatinny Arsenal, Dover, New Jersey

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

Charles Lenchitz, Gayton Silvestro

Technical Memorandum No. 1295, DA Proj. 1A0105013010 June 1963, 9 pp, tables.

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an Al_2O_3 residue. Calculation of the heat of formation from the reaction:

$C_6H_{24}O_{18}Cl_3N_{12}Al(s) + 3O_2(g) + 1789.5\ H_2O(l)$

$6CO_2(g) + 6N_2(g) + \frac{1}{2}\ Al_2O_3(c) + 3\ (HCl.600\ H_2O)$

gives a value of −691.53 kcal/mole (at constant pressure and 25°C).

UNCLASSIFIED

1. Perchlorates – Combustion
2. Title

I. Lenchitz, Charles
II. Silvestro, Gayton

UNITERMS

Heat
Formation
Hexaurea
Aluminum III
Perchlorate
Combustion
Bomb
Aluminum oxide

UNCLASSIFIED

AD Accession No.
Picatinny Arsenal, Dover, New Jersey

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

Charles Lenchitz, Gayton Silvestro

Technical Memorandum No. 1295, DA Proj. 1A0105013010 June 1963, 9 pp, tables.

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an Al_2O_4 residue. Calculation of the heat of formation from the reaction:

$C_6H_{24}O_{18}Cl_4N_{12}Al(s) + 3O_2(g) + 1789.5\ H_2O(l)$

$6CO_2(g) + 6N_2(g) + \frac{1}{2}\ Al_2O_3(c) + 3\ (HCl.600\ H_2O)$

gives a value of 691.53 kcal/mole (at constant pressure and 25°C)

UNCLASSIFIED

1. Perchlorates – Combustion
2. Title

I. Lenchitz, Charles
II. Silvestro, Gayton

UNITERMS

Heat
Formation
Hexaurea
Aluminum III
Perchlorate
Combustion
Bomb
Aluminum oxide

UNCLASSIFIED

AD Accession No.
Picatinny Arsenal, Dover, New Jersey

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

Charles Lenchitz, Gayton Silvestro

Technical Memorandum No. 1295, DA Proj. 1A0105013010 June 1963, 9 pp, tables.

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an Al_2O_3 residue. Calculation of the heat of formation from the reaction:

$C_6H_{24}O_{18}Cl_3N_{12}Al(s) + 3O_2(g) + 1789.5\ H_2O(l)$

$6CO_2(g) + 6N_2(g) + \frac{1}{2}\ Al_2O_3(c) + 3\ (HCl.600\ H_2O)$

gives a value of −691.53 kcal/mole (at constant pressure and 25°C).

UNCLASSIFIED

1. Perchlorates – Combustion
2. Title

I. Lenchitz, Charles
II. Silvestro, Gayton

UNITERMS

Heat
Formation
Hexaurea
Aluminum III
Perchlorate
Combustion
Bomb
Aluminum oxide

UNCLASSIFIED

AD Accession No.

Picatinny Arsenal, Dover, New Jersey

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

Charles Lenchitz, Gayton Silvestro

Technical Memorandum No. 1295, DA Proj. 1A0105013010 June 1963, 9 pp, tables.

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an Al_2O_3 residue. Calculation of the heat of formation from the reaction:

$C_6H_{24}O_{18}Cl_3N_{12}Al(s) + 3O_2(g) + 1789.5\ H_2O(l)$

$6CO_2(g) + 6N_2(g) + \frac{1}{2}\ Al_2O_3(c) + 3\ (HCl.600\ H_2O)$

gives a value of −691.53 kcal/mole (at constant pressure and 25°C).

UNCLASSIFIED

1. Perchlorates — Combustion
2. Title

I. Lenchitz, Charles
II. Silvestro, Gayton

UNITERMS

Heat
Formation
Hexaurea
Aluminum III
Perchlorate
Combustion
Bomb
Aluminum oxide

UNCLASSIFIED

AD Accession No.

Picatinny Arsenal, Dover, New Jersey

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

Charles Lenchitz, Gayton Silvestro

Technical Memorandum No. 1295, DA Proj. 1A0105013010 June 1963, 9 pp, tables.

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an Al_2O_3 residue. Calculation of the heat of formation from the reaction:

$C_6H_{24}O_{18}Cl_3N_{12}Al(s) + 3O_2(g) + 1789.5\ H_2O(l)$

$6CO_2(g) + 6N_2(g) + \frac{1}{2}\ Al_2O_3(c) + 3\ (HCl.600\ H_2O)$

gives a value of −691.53 kcal mole (at constant pressure and 25°C).

UNCLASSIFIED

1. Perchlorates — Combustion
2. Title

I. Lenchitz, Charles
II. Silvestro, Gayton

UNITERMS

Heat
Formation
Hexaurea
Aluminum III
Perchlorate
Combustion
Bomb
Aluminum oxide

UNCLASSIFIED

AD Accession No.

Picatinny Arsenal, Dover, New Jersey

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

Charles Lenchitz, Gayton Silvestro

Technical Memorandum No. 1295, DA Proj. 1A0105013010 June 1963, 9 pp, tables.

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an Al_2O_4 residue. Calculation of the heat of formation from the reaction.

$C_6H_{24}O_{18}Cl_3N_{12}Al(s) + 3O_2(g) + 1789.5\ H_2O(l)$

$6CO_2(g) + 6N_2(g) + \frac{1}{2}\ Al_2O_3(c) + 3\ (HCl\ 600\ H_2O)$

gives a value of 691.53 kcal/mole (at constant pressure and 25°C)

UNCLASSIFIED

1. Perchlorates — Combustion
2. Title

I. Lenchitz, Charles
II. Silvestro, Gayton

UNITERMS

Heat
Formation
Hexaurea
Aluminum III
Perchlorate
Combustion
Bomb
Aluminum oxide

UNCLASSIFIED

AD Accession No.

Picatinny Arsenal, Dover, New Jersey

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

Charles Lenchitz, Gayton Silvestro

Technical Memorandum No. 1295, DA Proj. 1A0105013010 June 1963, 9 pp, tables.

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an Al_2O_3 residue. Calculation of the heat of formation from the reaction:

$C_6H_{24}O_{18}Cl_3N_{12}Al(s) + 3O_2(g) + 1789.5\ H_2O(l)$

$6CO_2(g) + 6N_2(g) + \frac{1}{2}\ Al_2O_3(c) + 3\ (HCl.600\ H_2O)$

gives a value of −691.53 kcal/mole (at constant pressure and 25°C).

UNCLASSIFIED

1. Perchlorates — Combustion
2. Title

I. Lenchitz, Charles
II. Silvestro, Gayton

UNITERMS

Heat
Formation
Hexaurea
Aluminum III
Perchlorate
Combustion
Bomb
Aluminum oxide

UNCLASSIFIED

AD Accession No.

Picatinny Arsenal, Dover, New Jersey

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

Charles Lenchitz, Gayton Silvestro

Technical Memorandum No. 1295, DA Proj. 1A01050130l0 June 1963, 9 pp, tables.

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an Al_2O_3 residue. Calculation of the heat of formation from the reaction:

$C_6H_{24}O_{18}Cl_3N_{12}Al(s) + 3O_2(g) + 1789.5\ H_2O(l)$

$6CO_2(g) + 6N_2(g) + \frac{1}{2}\ Al_2O_3(c) + 3\ (HCl.600\ H_2O)$

gives a value of -691.53 kcal/mole (at constant pressure and 25°C).

UNCLASSIFIED

1. Perchlorates – Combustion
2. Title

I. Lenchitz, Charles
II. Silvestro, Gayton

UNITERMS

Heat
Formation
Hexaurea
Aluminum III
Perchlorate
Combustion
Bomb
Aluminum oxide

UNCLASSIFIED

AD Accession No.

Picatinny Arsenal, Dover, New Jersey

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

Charles Lenchitz, Gayton Silvestro

Technical Memorandum No. 1295, DA Proj. 1A01050130l0 June 1963, 9 pp, tables.

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an Al_2O_3 residue. Calculation of the heat of formation from the reaction:

$C_6H_{24}O_{18}Cl_3N_{12}Al(s) + 3O_2(g) + 1789.5\ H_2O(l)$

$6CO_2(g) + 6N_2(g) + \frac{1}{2}\ Al_2O_3(c) + 3\ (HCl.600\ H_2O)$

gives a value of -691.53 kcal/mole (at constant pressure and 25°C).

UNCLASSIFIED

1. Perchlorates – Combustion
2. Title

I. Lenchitz, Charles
II. Silvestro, Gayton

UNITERMS

Heat
Formation
Hexaurea
Aluminum III
Perchlorate
Combustion
Bomb
Aluminum oxide

UNCLASSIFIED

AD Accession No.

Picatinny Arsenal, Dover, New Jersey

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

Charles Lenchitz, Gayton Silvestro

Technical Memorandum No. 1295, DA Proj. 1A01050130l0 June 1963, 9 pp, tables.

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an Al_2O_3 residue. Calculation of the heat of formation from the reaction.

$C_6H_{24}O_{18}Cl_3N_{12}Al(s) + 3O_2(g) + 1789.5\ H_2O(l)$

$6CO_2(g) + 6N_2(g) + \frac{1}{2}\ Al_2O_3(c) + 3\ (HCl.600\ H_2O)$

gives a value of 691.53 kcal/mole (at constant pressure and 25°C).

UNCLASSIFIED

1. Perchlorates – Combustion
2. Title

I. Lenchitz, Charles
II. Silvestro, Gayton

UNITERMS

Heat
Formation
Hexaurea
Aluminum III
Perchlorate
Combustion
Bomb
Aluminum oxide

UNCLASSIFIED

AD Accession No.

Picatinny Arsenal, Dover, New Jersey

THE HEAT OF FORMATION OF HEXAUREA ALUMINUM III PERCHLORATE

Charles Lenchitz, Gayton Silvestro

Technical Memorandum No. 1295, DA Proj. 1A01050130l0 June 1963, 9 pp, tables.

Hexaurea Aluminum III perchlorate burns smoothly in a combustion bomb leaving an Al_2O_3 residue. Calculation of the heat of formation from the reaction:

$C_6H_{24}O_{18}Cl_3N_{12}Al(s) + 3O_2(g) + 1789.5\ H_2O(l)$

$6CO_2(g) + 6N_2(g) + \frac{1}{2}\ Al_2O_3(c) + 3\ (HCl.600\ H_2O)$

gives a value of -691.53 kcal/mole (at constant pressure and 25°C).

UNCLASSIFIED

1. Perchlorates – Combustion
2. Title

I. Lenchitz, Charles
II. Silvestro, Gayton

UNITERMS

Heat
Formation
Hexaurea
Aluminum III
Perchlorate
Combustion
Bomb
Aluminum oxide

UNCLASSIFIED